THE ROLE OF THE STETHOSCOPE IN PHYSICAL DIAGNOSIS.

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The object of auscultation is threefold: (1) It should bring to the ear intracorporeal sonorous vibrations; (2) from the nature of the sound we deduce the physical conditions producing it, and (3) finally we attempt to judge the significance of these conditions to the vital economy of the patient.

Mediate auscultation through the stethoscope is so well established that immediate auscultation by direct application of the ear to the body may well-nigh be numbered among the lost arts. Nevertheless, Conner[1] has called attention to the surprising fact that certain pathological sounds, as the diastolic murmur of aortic insufficiency and the amphoric note from the bronchi, may be missed through the stethoscope while plainly audible with the unaided ear. It is well to have such possibilities in mind when the constant refinement in instrumentation, particularly as manifested in the German clinic, is, as it were, making the methods of physical diagnosis more and more artificial. The designer of a stethoscope is happy to make the sounds which it transmits as loud as possible, yet he may be sure that this loudness is but the result of sympathetic vibration of the instrument itself, and it is hardly possible to construct an apparatus which will at once magnify in equal ratio all the tones that come to it. F. von Müller[2] has recently demonstrated that the normal inspiratory murmur is much lower in pitch than the note obtained from the trachea or bronchi. He used as a stethoscope-resonator a rubber tube whose length could be varied at will. It required a much longer tube to "speak" in response to the murmur of inspiration than to the note from the trachea. It is always to be suspected that any extraordinary intensity of auscultated sound is due to selective resonance on the part of the instrument used. The roar from a bullfrog's pouching chops probably represents inadequately the range of partial tones emitted from his larynx.

It may be admitted, as a general fact, that there is no such thing as a sonorous vibration within the chest, but it comes to the ear modified by the sympathetic resonance and conductive properties of the tissues of the thorax; judgments founded on auscultatory findings represent only the more or less conscious appreciation of the way in which sonorous vibrations are modified by definite physical changes in the tissues.

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[1] Certain Limitations of the Stethoscope (Binaural) and Their Clinical Importance, New York Med. Jour., 1907, lxxxvi, 56.

[2] Zur physikalischen Diagnostik, 1911, xxviii, Kong. f. innere Med., 181.

The simple fact of tactile fremitus is a demonstration of the power with which the wall of the chest may reproduce vibrations originating in the larynx. It has been pointed out by Coplin,[3] by the writer,[4] and by others, that certain pathological sounds have their origin in the chest wall itself, though they imitate the sonorous effects of underlying disturbances. The importance of the chest wall as a resonator for visceral vibrations has appealed to me for many years, and the belief has gradually developed that the experimental modification of mural vibrations during physical examination gives unwonted clarity to the perception of the conditions within the thorax. The procedures applicable to the examination of the heart were published in 1897,[5] while a consideration of them in the study of the lungs has recently been detailed.[6]

In brief the method purports to enable the examiner to apprehend at will the sonorous vibrations intrinsic to the thoracic viscera unconfused with those proper to the chest wall itself. This result is accomplished by damping the mural vibrations by pressure applied to the chest piece of the stethoscope. The astounding predominance of the mural component of the sounds to which we are accustomed to listen in the chest becomes especially obvious through the auscultation of those normal lungs in which vocalization is accompanied by considerable tactile fremitus—as in vigorous young men.

The powerful, resonant voicing heard through the stethoscope when applied lightly to the chest is usually turned into a flat, feeble, and distant sound when the bell of the instrument is pressed firmly upon the skin. This effect of stethoscopic pressure is much more marked below the level of a plane transecting the body at about the level of the fourth rib in front. As was pointed out in a previous paper,[7] the vibrations of the air in the trachea and large bronchi penetrate more or less freely directly to the parietes of the upper part of the thorax and are there not annulled by stethoscopic pressure. The sounds heard in the lower parts of the chest are to a much larger proportion made up of sympathetic vibrations of the parietes. This is well demonstrated in the auscultation of the normal inspiratory murmur when it is strongly diffused; pressure usually annuls the murmur over the lower areas, but not above. The normal, breezy inspiratory murmur when not annulled is usually greatly diminished by stethoscopic pressure, and is rendered sharper, more bronchial, and higher in pitch. These facts have led me to the revolutionary opinion that the normal inspiratory murmur owes its pitch, volume, and quality chiefly to sympathetic vibration of the chest wall.

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[3] Amer. Jour. Med. Sci., 1904, cxxvii, 754.

[4] Sewall, The Origin of the "New-leather" and "Dry-friction" Sounds Heard on Auscultation, Amer. Jour. Med. Sci., 1909, cxxxvii, 364.

[5] Sewall, The Use of Stethoscopic Pressure in Physical Examination of the Heart, New York Med. Jour., 1897, vol. lxvi.

[6] Sewall and Childs, A Comparison of Physical Signs and X-ray Pictures of the Chest in Early Stages of Tuberculosis, Arch. of Int. Med., 1912, x, 45.

[7] Sewall and Childs, loc. cit.

The influence of the main bronchi on the transmission of sound was recently illustrated in the case of a right-sided serous effusion which reached to about the level of the middle of the scapula. Whispered sounds were plainly transmitted throughout the area of dulness, but failed just above it. When the fluid was aspirated so that its level fell to about the angle of the scapula the whispered sounds could no longer be heard over the remaining effusion. In the first case probably vibrations were taken up by the fluid directly from the right bronchus and its main descending branches, while in the second case the fluid had fallen below the great air vessels and therefore failed to pick up their vibrations.

When the voice is auscultated over a serous effusion in the ordinary way it may show no specific change in character, but on applying pressure the pitch is raised and the quality and duration of the sound are altered in a characteristic manner.

Now if we may assume that the fundamental tone of the chest wall remains practically unchanged while extensive pathological disorders develop in the viscera, it follows that any modification of auscultated sounds due to alteration of conductivity or resonance in the viscera must be relatively exaggerated by any procedure which annuls the mural vibrations. Stethoscopic pressure dampens the mural vibrations and presents to the ear the real acoustic changes in the viscera. The student will observe that the invariable effect of pressure applied to the stethoscope is to raise the pitch of the auscultated note, apparently by cutting off its fundamental and lower partial tones. It has been pointed out by von Müller[8] that the "chest tones" of the voice, which especially invoke the resonance of the thoracic parietes, belong distinctly to the lower part of the register because the fundamental tone of the chest wall is one of slow vibration.

Interesting results are obtained on auscultating, both without and with pressure of the stethoscope, the normal chests of persons with good singing voice. When a high or "head" note is voiced and held, the sound as heard through the stethoscope applied to the upper chest is little changed, though it is apt to be made more intense and brought nearer the ear by pressure. Near the base of the lungs, pressure decreases the intensity of the sound, but in neither case is there a marked change in the pitch or quality of the note. On voicing a low or "chest tone," however, pressure applied to the stethoscope produces extraordinary changes in the sound. With pressure the fundamental tone and apparently the lower partials are damped and the pitch and quality of the transmitted tone are altered and its intensity diminished. It must be borne in mind that it is possible for the thoracic viscera to undergo more or less profound pathological changes without essential modification in their acoustic properties. In such exceptional cases the results of stethoscopic pressure would be negative. Also, although modification from the normal of sounds heard with stethoscopic pressure determines visceral changes with unparalleled delicacy, the specific nature of these changes is not thereby determined; we only apprehend that *something* is the matter.

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[8] Diagnostik der Lungenkrankheiten, Zeitsch. f. ärztliche Fortbildung., 1912, ix, Nr. 14.

In previous writings on this subject I have indicated that to successfully damp the vibrations of the chest wall through stethoscopic pressure the physical structure of the stethoscope itself is of fundamental importance. Further study has led to the more definite discrimination of the physical principles involved in the application of "stethoscopic pressure," and briefly to set them forth is the object of this paper.

A solid body laid upon the chest wall takes up and transmits according to its own elastic properties the vibrations emanating from the latter. When the pressure of the solid body upon the surface is sufficiently increased the sensible vibrations of the latter are damped, but their energy is, of course, transferred to the body which extinguished them. When, for example, the uniaural, solid stethoscope is applied to the chest the sounds heard through it are not deadened by increasing the pressure of contact; on the contrary, they tend to become more intense, and are brought nearer the ear.

The same result is obtained with the use of the binaural air-conducting stethoscope, in which the ear and chest pieces are connected by a conducting solid medium, such as a spiral wire. With the simplest form of binaural stethoscope, however, in which the ear and chest pieces are joined by plain rubber tubes, the results of pressure are wholly different. If the bell of such a stethoscope is thick-walled and has a high fundamental tone the damped mural vibrations do not sensibly affect it, and therefore there come to the ear only such vibrations as are transmitted from the viscera of the thorax through the disk of tissue enveloped by the stethoscope bell. If the chest-piece of the stethoscope is thin-walled, and therefore easily set into vibration, or, as in certain popular and excellent instruments, is provided with a disk designed to vibrate, the vibrations set up in the chest piece will not be annulled by pressure, but will be transmitted to the air of the rubber tubes and conducted to the ears.

Our conclusions may be condensed as follows: The sounds heard in auscultation of the chest are compounded of both visceral and mural vibrations, of which the latter, especially in the lower parts of the musical scale, may greatly preponderate in intensity, but of which the former are alone usually of clinical interest.

The *quasi* adventitious sounds due to sympathetic vibration of the chest wall may be damped and rendered more or less inaudible by firm pressure applied to the bell of the stethoscope. In order to thus annul the sound from mural vibrations the instrument must transmit by pure air conduction, and its chest-piece must not itself sensibly take up the vibrations of the chest wall.

A CLINICAL AND EXPERIMENTAL INVESTIGATION OF THE THERAPEUTIC VALUE OF CAMPHOR.

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The profession has long felt the need of a more accurate knowledge in regard to the relative value of the several drugs employed as so-called "circulatory stimulants." Since this problem first occupied the minds of the writers, important contributions have been made. The present communication appears to be justified, nevertheless, because of the obscurity which still surrounds many members of the group. Thus as concerning the therapeutic value of camphor there has been so far rather more of speculation than of positive knowledge.

A study of some of these drugs was contemplated by us as early as the autumn of 1909. However, the present research was directly stimulated by observation of the following case: In the spring of 1910 a relative of one of us died as the result of a widespread infection, secondary to a suppurative cholecystitis. During the last three weeks of the patient's life there were several periods of alarming circulatory breakdown, occurring during the course of a clinical auricular fibrillation. These acute seizures were apparently due to the action of the infective agents upon the myocardium and vasomotor apparatus. During the attacks, attempts were made to improve the mass movement of blood by the hypodermic administration of such substances as caffein, strychnine, and camphor. The use of camphor was followed in more than one instance by a marked temporary improvement in the character of the pulse and in the general condition of the patient. Nevertheless, the general course of the disease was downward.